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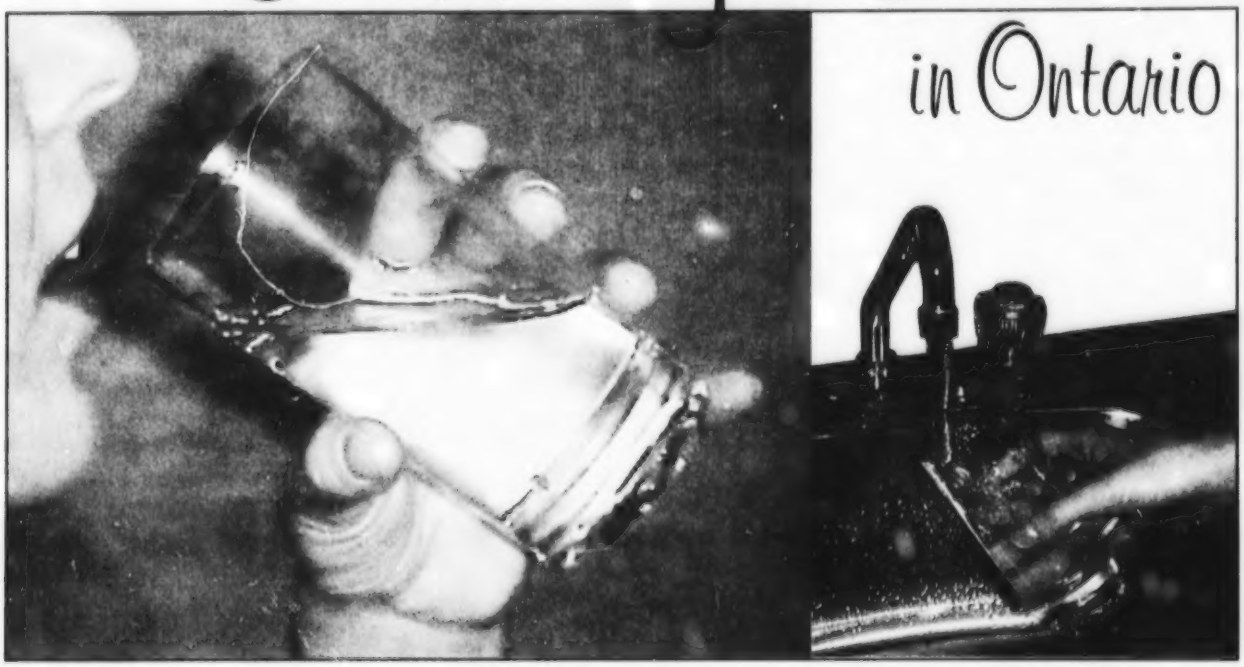
Ontario

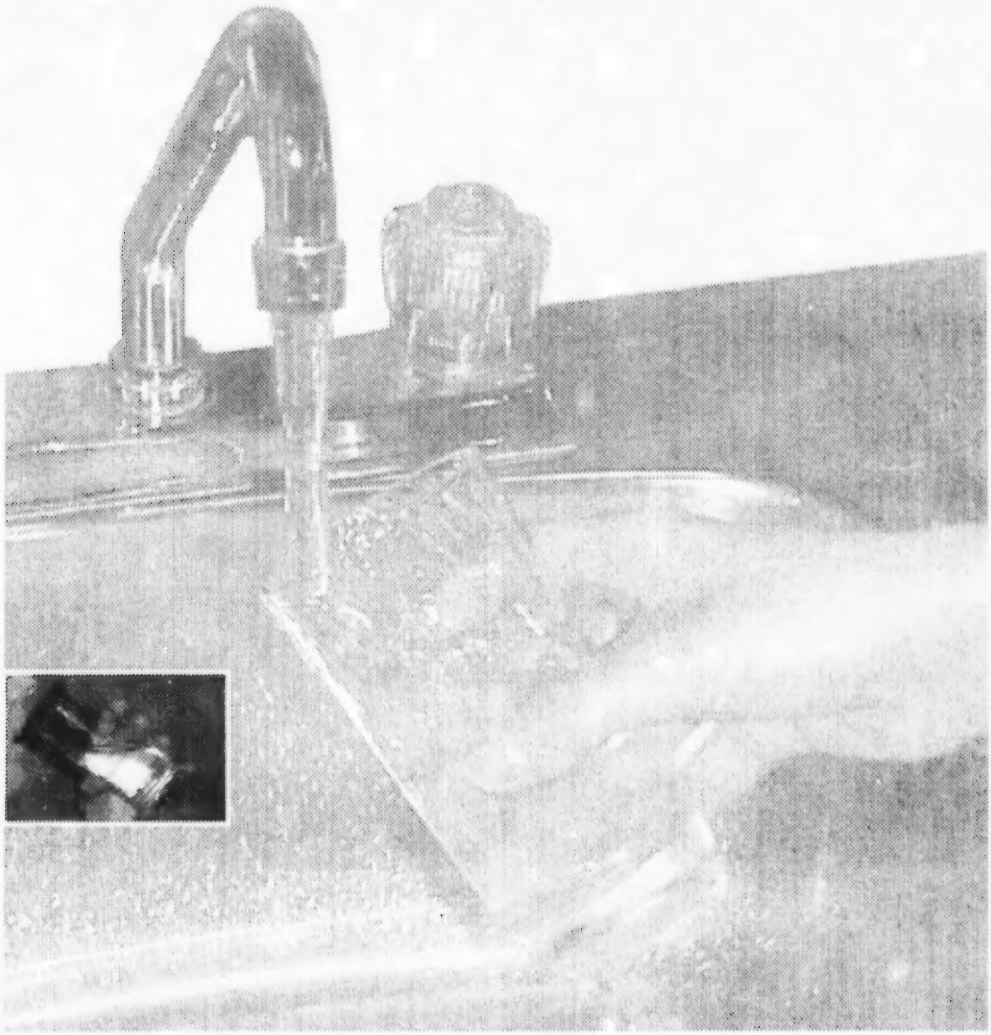
Drinking Water in Ontario



A SUMMARY REPORT 1993 — 1997

Ministry of the Environment

Drinking Water in Ontario



Ministry of the Environment
Environmental Monitoring and Reporting Branch
Water Monitoring Section

Ce document technique n'existe qu'en anglais.

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Preface

Site-specific reports for water supply systems monitored as part of the Drinking Water Surveillance Program (DWSP) of the Ministry of the Environment are available from the ministry's Public Information Centre at 135 St. Clair Ave. West, 1st floor, Toronto, or at the toll free number 1-800-565-4923. The 1993-1995 and 1996-1997 reports list all analytical data generated by the DWSP. An electronic copy of the Executive Summary for each water supply system can be downloaded from the ministry's Web site at www.ene.gov.on.ca.

Additional information about drinking water quality for a specific water supply system can be obtained by contacting the local municipal office or public utilities commission.

Information about DWSP is available by calling the ministry at 416-235-6229 or by contacting the Water Monitoring Section of the Environmental Monitoring and Reporting Branch at 125 Resources Rd., Etobicoke ON M9P 3V6.

Executive Summary

Drinking Water in Ontario discusses the quality of municipal drinking water in Ontario, the pertinent legislation and regulations, the roles and responsibilities of governing agencies and the chemistry of Ontario's drinking water. A comparison is made to drinking water programs delivered by other agencies in Australia, Europe, Japan, South Africa, United States, United Kingdom, Alberta and Quebec.

In Ontario approximately 8.9 million people receive their drinking water from municipal water works, 82% of the total population. The remaining population is serviced by individual wells or other private water sources. Sixty-six per cent of the population serviced by municipal water receive drinking water from the Great Lakes basin.

Of the approximately 627 municipal water works in Ontario, 399 use ground water, 225 surface water and three combined surface and ground water sources. These water works are legislated under the Ontario Water Resources Act (OWRA), which the Ministry of the Environment (MOE) is responsible for administering. Each municipality is responsible for ensuring that water of adequate quality is delivered to the consumer. Private owners of water works falling under the OWRA are fully responsible for the quality of water they deliver to the consumer.

The operating authority, municipal or private, is responsible for monitoring the drinking water to ensure that it satisfies the Ontario Drinking Water Objectives. Compliance with the monitoring requirements is audited by staff under the ministry's Sewage and Water Inspection Program (SWIP). Water works that are not capable of supplying water at a rate greater than 50,000 litres per day, or that supply water for five or fewer private residences, are not governed under the OWRA and are the responsibility of local health agencies.

The ministry's Environmental Science and Standards Division, Environmental Monitoring and Reporting Branch, delivers the Drinking Water Surveillance Program (DWSP), a monitoring program developed to provide reliable and current information on municipal drinking water. Data collected by the DWSP are used to monitor contaminant levels and trends, define the emergence of new contaminants, support drinking water standards development and assess the efficiency of treatment processes in water works. As of year-end 1997, 145 water works were monitored as part of the DWSP. This represents 88% of the population serviced by municipal water. Samples of the untreated source water, treated water and water from the distribution system are analysed for over 200 parameters including the Ontario Drinking Water Objectives (ODWOs).

The MOE performed 654,382 analytical tests for chemical and physical parameters on municipal drinking water during the period 1993-1997. Of these, 99.98% met health-related Ontario Drinking Water Objectives. Forty-six municipal water supplies had results above the health-related ODWOs on at least one occasion; most were isolated, single occurrences. The health-related objectives were exceeded in 101 tests for one of the following parameters: fluoride, lead, nitrate, N-nitrosodimethylamine (NDMA), total trihalomethanes (THMs) and turbidity. Microbiological parameters were not included in the testing performed by the MOE; testing of microbiological quality is conducted by the operating authority, which is required to report adverse results to the local Medical Officer of Health.

Ontario is blessed with an abundant supply of good quality source water, surface and ground water. Results of the Drinking Water Surveillance Program continue to demonstrate that the drinking water provided to the consumer is of good quality. In fact the quality of Ontario's drinking water compares with or surpasses the quality of that provided by other jurisdictions.

Contents

OWRA

Ontario Water Resources Act

1
Responsibility and Accountability

1.1
Legislation and Regulation

Each Canadian province has jurisdiction over its own potable water supplies. In Ontario, the Ontario Water Resources Act (OWRA), enacted in March 1966, is the legislation that governs potable water. Ontario's first environmental statute, the OWRA prohibits the pollution of water, requires the approval of water works[1] and sewage works and governs the taking of water and construction of wells.

The Ministry of the Environment (MOE) has responsibility to administer this Act. Under Section 52 of the OWRA, the MOE must grant approvals for the establishment of any water works or the extension of or change to any existing water works. The requirement for MOE approval does not apply to the following: water works to be used only for supplying water for agricultural, commercial, or industrial purposes, that is not required under any Act or regulation to be fit for human consumption; water works not capable of supplying water at a rate greater than 50,000 litres per day; water works to be used to supply water for five or fewer private residences; and water works that have been exempted by regulations made under this Act.

Water works such as those supplying water to First Nations reserves and armed forces bases are under federal jurisdiction and thereby exempt from provincial legislation. Water works not governed under the OWRA are the responsibility of local health agencies.

The local Medical Officers of Health, through the Health Protection and Promotion Act (Chapter 10, Part 3, sections 10,11,12,13) have the authority to judge whether water is safe for human consumption.

Ontario Regulation 435/93 requires that water works be classified and that persons operating water works be licensed according to the classification held by the water works. The regulation prescribes the qualifications of persons to whom the licences may be issued and provides for the revocation and suspension of licences.

1.2
Responsibility

The MOE, through the administration of Water Management Guidelines and Procedures B-13 and B-14, enforces minimum treatment requirements for water works utilizing surface water and/or ground water. Guideline B-13 requires that all water works in the province utilizing surface water (i.e. lakes, rivers, streams etc.) as a source of raw water shall use treatment processes consisting of coagulation-flocculation, filtration and disinfection. Guideline B-14 requires that all water works utilizing ground water as a source of raw water shall be provided with a treatment process consisting of disinfection as a minimum. Variance requests from Guidelines B-13 or B-14 are reviewed on an individual basis.

Construction of new water works or alterations to existing works may proceed only after a Certificate of Approval under Section 52 of the OWRA has been issued by the MOE. The decision for approval of water supplies may be based on: adequate quantity and satisfactory quality of the water source; adequate treatment facilities to consistently produce water that meets objectives and guidelines; adequate capacity to meet peak demands; enforcement of requirements to prevent development of health hazards; and other sound engineering principles. Certificates of Approval designate the standards that drinking water quality must meet and the monitoring requirements to assess drinking water quality. MOE Operations Division staff are responsible for ensuring that water works operators comply with their Certificates of Approval.

In general the municipality is responsible for the treatment and distribution of water. Where a public utilities commission or pri-

[1] Water works: any works for the collection, production, treatment, storage, supply and distribution of water, or any part of such works, but does not include plumbing or other works to which regulations made under clause 75 (3) (a) of the OWRA apply.

vate entity is responsible for the treatment and distribution of water, it acts as a statutory agent for the municipality. The municipality therefore remains ultimately responsible for ensuring that water of adequate quality is delivered to the consumer. Private owners of water works falling under the OWRA are fully responsible for the quality of water delivered.

1.3

Standards of Drinking Water Quality

Standards for drinking water quality are developed nationally under the auspices of Health Canada as "guideline limits."

A risk assessment process is used to set drinking water limits. When assessing the cancer and non-cancer risks from exposure to a chemical in drinking water, the first step is to measure how much of the chemical could be in the water. Next, scientists estimate how much of the chemical the average person is likely to drink. This amount is called the exposure. In developing drinking water limits it is assumed that the average adult drinks 1.5 litres of water each day throughout a 70-year lifespan. The risks for cancer and non-cancer effects are estimated separately. For cancer effects, a risk assessment estimates a measure of the chances that someone may get cancer because he or she has been exposed to a drinking water contaminant. Limits are set at levels that will limit a person's risk of cancer from that contaminant to between one in 10,000 and one in 1,000,000 over a lifetime. For non-cancer effects, the risk assessment estimates an exposure level below which no adverse effects are expected to occur.

1.3.1

Canadian Drinking Water Guidelines [I]

The Federal-Provincial Subcommittee on Drinking Water, composed of representatives from each of the Canadian provinces and territories, Environment Canada and Health Canada, has the responsibility for establishing a guideline limit. The guideline limit is based on the concentration proposed by the risk assessment process in conjunction with a risk management process that reviews scope and prevalence of the contaminant, available treatment technology and associated costs. The guideline limits are published every two years in the document Guidelines for Canadian Drinking Water Quality.[I]

1.3.2

Ontario Drinking Water Objectives [II]

Ontario Drinking Water Objectives (ODWOs) (Appendix I) are the provincial standards of drinking water quality adopted from the guideline limits established by the Federal-Provincial Subcommittee on Drinking Water. Several provinces, including Ontario, set unique limits specific to their provincial drinking water quality. The ODWOs are administered through MOE Guideline B-5 and may be enforced under the OWRA through the issuance of Certificates of Approval or by Director's Order.

The primary purpose of Drinking Water Objectives is to protect public health. Water intended for human consumption should not contain disease-causing organisms or hazardous concentrations of toxic chemicals or radioactive parameters. Drinking water should also be aesthetically pleasing. Maximum Acceptable Concentrations (MAC) and Interim Maximum Acceptable Concentrations (IMAC) are health-related objectives established for parameters (Table 1) that when present above a certain concentration have known or suspected adverse health effects. The length of time the MAC can be exceeded without injury to health is dependent on the nature and concentration of the parameter.

Objectives are also set for non-health related parameters (Table 2). Aesthetic objectives are established for parameters that may impair the taste, smell or colour of

[I] Guidelines for Canadian Drinking Water Quality, Sixth Edition, Minister of Supply and Services Canada 1996, ISBN 0-660-16295-4
www.hc-sc.gc.ca/ehp/ehd/catalogue/bch_doc.htm

[II] Ontario Drinking Water Objectives, Revised 1994, Ontario Ministry of the Environment, ISBN 0-7743-8985-0

water. Operational guidelines are established for parameters which need to be controlled to ensure efficient treatment and distribution of the water.

Table 1

Health Related-Ontario Drinking Water Parameters

Chemical/Physical

Alachlor
Aldicarb
Aldrin + Dieldrin
Arsenic
Atrazine
(+ N-dealkylated metabolites)
Azinphos-methyl
Barium
Bendiocarb
Benzene
Benzo(a)Pyrene
Boron
Bromoxynil
Cadmium
Carbaryl
Carbofuran
Carbon Tetrachloride
Chlordane
Chlorpyrifos
Chromium
Cyanazine
Cyanide
Diazinon
Dicamba
1,2-Dichlorobenzene
1,4-Dichlorobenzene
DDT (+metabolites)
1,2-Dichloroethane
Dichloromethane
2,4-Dichlorophenol
2,4-D
Diclofop-methyl
Dimethoate
Dinoseb
Dioxin and Furan
Diquat
Diuron
Fluoride
Glyphosate
Heptachlor + Heptachlor Epoxide
Lead
Lindane
Malathion
Mercury
Methoxychlor
Metolachlor
Metribuzin
Monochlorobenzene
Nitrate (as nitrogen)
Nitrate + Nitrite (asN)
Nitrite
Nitrilotriacetic Acid (NTA)
Nitrosodimethylamine (NDMA)
Paraquat
Parathion
Pentachlorophenol
Phorate
Picloram
PCB
Prometryne
Selenium
Simazine
Temephos
Terbufos
2,3,4,6-Tetrachlorophenol
Triallate
Trichloroethylene
2,4,6-Trichlorophenol
2,4,5-T
Trifluralin
Trihalomethanes
Turbidity
Uranium
Vinyl Chloride

Microbiological

Total Coliforms
Escherichia coli and/or
Fecal Coliforms
General Bacterial Population

Radiological

Cesium-137
Iodine-131
Radium-226
Tritium
Strontium-90

Table 2

Non-Health-Related Ontario Drinking Water Objectives

Alkalinity (as CaCO3)
Aluminum
Chloride
Colour
Copper
Dissolved Organic Carbon
Ethylbenzene
Hardness (as CaCO3)
Iron
Manganese
Methane
Odour
Organic Nitrogen
pH
Sodium
Sulphate
Sulphide
Taste
Temperature
Toluene
Total Dissolved Solids
Xylenes

2
Protection of Drinking Water

2.1
Municipal Drinking Water

Ontario has approximately 627[2] municipal water works providing drinking water to 82% of the population. The remaining 18% of the population receive water from individual wells or other private water sources. Seventy-seven per cent of the water works are owned and operated by municipalities or public utility commissions. The Ontario Clean Water Agency (OCWA) operates approximately 19% of Ontario's water works under contract with municipalities. Eight water works are operated by private contractors. Five water works, all in Northern Ontario, are privately owned and operated. One water works is owned and operated by a local services board and one is an institutional system owned by the Province of Ontario.

[2] As a result of municipal regionalization and amalgamation the operating authority of any water works may undergo change. The numbers quoted are based on the most recent information available.

These 627 water works take water from varying sources; 399 use ground water, 225 surface water, and three use combined ground and surface water. Table 3 shows the number of water works versus population served and Table 4 shows the population served according to source water type. Seventeen water works provide drinking water to over 65% of Ontarians serviced by municipal drinking water. Over 74% of all water works are small systems providing drinking water to communities of 3,300 people or less.

Table 3

Ontario Water Works and Population Served

Water Works Size by Population*	Number	Total Population Served
≤500	216	40,688
510-3300	229	322,649
3301-10,000	83	487,066
10,001-100,000	61	2,140,292
>100,000	17	5,695,595
*21 unreported	627*	8,686,290

2.2
Bottled Water

Bottled (prepackaged) water is regulated under the Federal Food and Drug Act and therefore lies within the mandate of Health Canada. Division 12, B.12.001 – B.12.009 of the Food and Drug Act details the labelling and packaging requirements. Microbiological quality, coliform bacteria and fluoride ion concentration are the sole parameters regulated under the Act. The Act does not prescribe any monitoring protocol nor require water quality to conform with prescribed limits for drinking water.

2.3
Drinking Water Characteristics

In Ontario, drinking water is provided from rivers, lakes, streams, ponds, reservoirs, springs and wells. As water travels through the ground or over the surface, it dissolves minerals and can also pick up contaminants of animal, human or industrial origin. Categories of contaminants that may be present in source waters include:

- bacteriological substances, such as viruses and bacteria, which may come from sewage treatment plants, septic systems, agricultural livestock operations and wildlife;

Table 4

Ontario Water Works and Source Waters

Water Works Size by Population	Ground water	Surface water	Combined
≤500	175	40	1
501-3300	153	76	
3301-10,000	37	45	1
10,001-100,000	19	41	1
>100,000	1	16	

- inorganic substances, such as salts and metals, which can be naturally occurring or result from urban storm water run-off, industrial or domestic wastewater discharges, oil and gas production, mining or farming;
- pesticides and herbicides, which may come from a variety of sources such as agriculture, storm water run-off and residential use;

- organic substances, synthetic and volatile, which are by-products of industrial processes and petroleum production and can come from gas stations, urban storm water run-off and septic systems;
- radioactive substances, which can occur naturally or result from nuclear power production and mining activities.

2.4
Drinking Water Monitoring

All water works capable of supplying water at a rate greater than 50,000 litres per day or that serve more than five private residences are subject to the Ontario Water Resources Act. The operating authority is responsible for monitoring the drinking water to ensure that it satisfies the Ontario Drinking Water Objectives (ODWOs). The monitoring protocol may be outlined in the Certificate of Approval issued for each water works. In the absence of a Certificate of Approval or specified monitoring protocol, the MOE minimum sampling requirement is outlined in the ODWOs. Compliance with the monitoring protocol is audited by staff under the MOE Sewage and Water Inspection Program (SWIP). Communal water works must have monitoring results available for inspection by the MOE and are obligated to submit a report upon request. Some municipalities produce water quality reports for their own customers. Through the performance of targeted inspections under the SWIP, the ministry audits compliance with the drinking water quality standards and the monitoring requirements cited in the site-specific Certificate of Approval or the ODWOs.

The ministry's Environmental Monitoring and Reporting Branch, Environmental Science and Standards Division, conducts the Drinking Water Surveillance Program (DWSP), a monitoring program developed to provide reliable and current information on municipal drinking water. Data collected by DWSP are used to monitor contaminant levels and trends, define the emergence of new contaminants, support drinking water standards development and assess the efficiency of treatment processes in water works.

3
Drinking Water Surveillance Program (DWSP)

3.1
Scope

The Ontario DWSP began in 1986 at 22 water works. By the end of 1997, 145 municipal water works were being monitored (Appendix II). This represents 88% of the population served by municipal water. Water works are prioritized for inclusion into the DWSP based on population exposure, geographical location, risk of contamination and availability of analytical services. New water works are added to the DWSP on an ongoing basis (as of March 1999, 159 were being monitored).

Samples are collected by trained water works staff, according to the standardized DWSP protocol (demonstrated in a MOE training video), at various stages throughout the course of treatment and distribution. Samples are taken of the source water, the treated water prior to entering the distribution system, and water from at least one location within the distribution system that is representative of the water at the consumer's tap. Sampling frequency varies from two to six times annually depending on the source water type and geographical location. Surface water quality, particularly in rivers, can vary from hour to hour or day to day depending on flow rate, depth, weather conditions and industrial or agricultural activity; ground water quality is much more stable. Water works using surface water sources are therefore sampled more frequently than ground water sources.

Stringent DWSP sampling protocols are followed to ensure that all samples are collected in a uniform manner. Sample lines are flushed prior to sampling to ensure that the water obtained is representative of what is flowing through the distribution system. In order to obtain a representative source water sample, water works that pre-chlorinate at the intake for zebra mussel control are required to turn off the chlorine feed and allow sufficient time for the chlorinated water to clear from the intake works before collecting the raw water sample.

A free flowing sample is taken at all distribution system locations; i.e. the tap is flushed for five minutes prior to sampling to ensure that the sample is representative of the water in the distribution main.

Water works are monitored for the presence of approximately 200 parameters (Appendix III), including the Ontario Drinking Water Objectives (health, aesthetic and operational). All DWSP analyses are conducted at the MOE laboratory with the exception of radionuclides, which are analysed at the Ministry of Labour Radiation Protection Services laboratory. Annually, one sample of the raw and treated water collected from each water works is screened for the complete spectrum of organic chemicals.

3.2
Ontario Drinking Water Surveillance Program Results

The DWSP results show that municipal water suppliers produced good quality drinking water for their communities. During the period 1993-1997, the MOE performed 654,382 analytical tests on Ontario municipal drinking water, both on the water as it left the treatment facility and at the consumer's tap; 99.98% met health-related Ontario Drinking Water Objectives (ODWOs).

Forty-six water supplies had results above the health-related ODWOs; most were isolated, single occurrences. The health-related objectives were exceeded in 101 tests for one of the following six parameters: fluoride, lead, nitrate, N-nitrosodimethlyamine (NDMA), total trihalomethanes (THMs) and turbidity (Appendix V).

According to DWSP protocol, when a result exceeds an ODWO the operating authority is notified and requested to report back to the MOE on any remedial action taken.

3.2.1

Microbiological Parameters

Under the ODWOs and site-specific Certificates of Approval, operating authorities are required to sample for selected microbiological parameters on a daily/weekly basis. The number of samples required is dependent on the population served but is a minimum of nine samples per month. The operating authority is required to report adverse results to the local Medical Officer of Health and take remedial action.

Full interpretation of microbiological quality cannot be made on the basis of the single samples taken by the DWSP in the period 1993-1997. Standard plate count was the single microbiological test conducted on the treated and distributed water. DWSP results show that the ODWO for standard plate count was never exceeded in treated drinking water.

In view of the intensive sampling conducted by individual municipalities, sampling for microbiological parameters by the DWSP was discontinued in 1996.

Cryptosporidium is a protozoan parasite transmitted by feces of infected humans and animals. There are a number of species of *Cryptosporidium* with one, *C. Parvum*, identified as the cause of disease in humans (cryptosporidiosis). No guideline value has been proposed for *cryptosporidium* and routine monitoring is not recommended because of the lack of a reliable and efficient method for identification.

The Ministry of Health, Public Health Branch, has prepared a guidance document for municipalities and local Medical Officers of Health to manage the detection of *Cryptosporidium*. It recommends that any decision on testing or the issuance of a boil-water advisory be supported by epidemiological information confirming increases in diarrheal disease in the community and data to suggest unacceptable water quality.

Giardia, a waterborne parasite, has been associated with many outbreaks of illness associated with drinking water, particularly in North America. There are a number of species of *Giardia* but human infections (giardiasis) are usually assigned to one, *Giardia intestinalis*. *Giardia intestinalis* infections have been reported from domestic and wild animals but the host range of human infectious species is uncertain. No guideline value has been proposed for Giardia and routine monitoring is not recommended because of the lack of a reliable and efficient method for identifying human infectious organisms. The protocol for dealing with the presence of *Giardia* is the same as that for *Cryptosporidium*.

Surface water sources are particularly vulnerable to *cryptosporidium* and *giardia* contamination. The source water may be contaminated by recreational use, sewage or sanitary discharges, or livestock operations in the watershed area. A well operated and monitored multiple-barrier system (i.e., coagulation, flocculation, sedimentation, filtration, disinfection or other individual water treatment processes) is critical to the effective removal of these parasites.

3.2.2

Taste and Odour Causing Parameters

Taste and odour episodes in surface water supplied drinking water have become more prevalent in Ontario over the past five years. They are caused by the decomposition of blue-green algae and generally occur after the algae blooms in the late summer. The compounds most frequently associated with taste and odour are *geosmin* and *MIB (2-methylisoborneol)*. *Geosmin* and *MIB* can impart nuisance taste and odour at very low levels (<10 ng/L). No health-related or aesthetic guidelines have been established. The highest value reported for *geosmin* was 69 ng/L and for *MIB* 17 ng/L.

Geosmin and *MIB* are not monitored routinely under the DWSP; however, special surveys are conducted at selected sites during specific times of the year. When water works experience taste and odour problems they can request special sampling for these parameters.

3.2.3

Inorganic Parameters

Physical/Chemical

For the most part, physical/chemical parameters are naturally occurring in the source water. The water treatment process is designed to reduce the levels of these parameters.

Fluoride is an additive that may be added to municipal water during the treatment process to reduce tooth decay. Fluoride can also be present in the source water as a result of dissolution of mineral deposits or discharge from fertilizer and aluminum factories. Consumption of water containing fluoride well in excess of the ODWO over many years could result in bone disease (pain and tenderness). The Ministry of Health recommends that the local Medical Officer of Health be notified of areas with high levels of naturally occurring fluoride. Water works having fluoride results above the ODWO were advised to optimize their fluoridation process. Fluoride accounted for 11% of all exceedances.

Nitrates are present in source water as a result of run-off from fertilizer use, leaching from septic tanks, sewage and dissolution of mineral deposits. There is a causal relationship between the presence of nitrate in drinking water and *infantile methaemoglobinaemia* or blue-baby syndrome. Adults who consume this water over many years could experience kidney or spleen problems. The ODWO for nitrate was exceeded in four test results from three water works. One water works has since switched to an alternative water source.

Turbidity in water is caused by the presence of suspended matter, such as clay, silt and microscopic organisms, and is commonly present in the source water as a result of soil run-off. Turbidity can serve as a source of nutrients for micro-organisms and interfere with their enumeration. The most important potential health effect of turbidity is its interference with disinfection and as an indicator of poor filtration. Turbidity values greater than the ODWO of 1 FTU, for water entering the distribution system, accounted for 40% of all exceedances.

Metals

For the most part, metals are present in source water naturally or as a result of industrial activity. Some, such as copper and lead, may enter the drinking water during water distribution.

Lead can occur in source water as a result of dissolution of mineral deposits. The most common source of lead is the corrosion of household plumbing. First flush water at the consumer's tap may contain higher concentrations of lead than water that has been flushed for several minutes. Infants and children who consume water in excess of the ODWO could experience delays in their physical or mental development. Some children could show slight deficits in attention span and learning abilities. Adults who consume this water over many years could develop kidney problems or high blood pressure, or may be at increased risk of developing some form of cancer. Lead accounted for 16% of all exceedances.

Mercury and *cyanide* have never been detected above a trace level in DWSP results for treated water.

3.2.4

Organic Parameters

Organics make up 83% of the total DWSP parameter test list yet they are seldom detected in drinking water.

Organic parameters are grouped accordingly:

Chloroaromatics

Parameters classified as chloroaromatics are present in surface water as a result of industrial activity. They are by-products of certain processes of chlorination of hydrocarbons. Fourteen chloroaromatics are tested for in the DWSP; two were detected. *Hexachlorobutadiene* was detected once at one water works and *hexachloroethane* was detected in samples from 10 water works to a maximum value of 27 ng/L. There are no ODWOs established for chloroaromatics.

Chlorophenols

The ODWO for total phenols was replaced by ODWOs for specific, more sensitive individual chlorophenols. Ten chlorophenols are

tested for in the DWSP; 2,4,6-trichlorophenol was the only chlorophenol detected. The ODWO for *2,4,6-trichlorophenol* in drinking water is 5000 ng/L (0.005 mg/L). It was detected in the treated water at seven water works ranging from 20 – 393 ng/L.

Disinfection By-products
Trihalomethanes (THMs), by-products of drinking water chlorination, form during the treatment process. The significant trihalomethanes are *bromoform, chloroform, bromodichloromethane* and *chlorodibromomethane*. People who consume water containing THMs in excess of the ODWO over many years may be at increased risk of developing some form of cancer. The pre-1996 ODWO of 350 µg/L for trihalomethanes was exceeded on two occasions at two water works. The ODWO was lowered to 100 µg/L (based on a running average of four quarterly samples) in June 1996. Three water works exceeded the revised ODWO.

Haloacetic Acids (HAAs) are another category of disinfection by-products that will always form in chlorinated waters as a result of the water treatment process. Haloacetic acids are composed of *Monochloroacetic Acid, Dichloroacetic Acid, Trichloroacetic Acid, Monobromoacetic Acid, Bromochloroacetic Acid,* and *Dibromoacetic Acid*. Results are reported for the individual compounds as well as for total HAAs. At present there is no Ontario Drinking Water Objective (ODWO) for HAAs.

N-nitrosodimethylamine (NDMA)
N-nitrosodimethylamine (NDMA) or its precursors may be present in the source water as a result of industrial discharge or from sewage/animal waste effluents combined with nitrite from anaerobic decay of organic waste matter. NDMA has been detected as a by-product in a certain blend of coagulant and polymer used in the treatment process. People who consume water containing NDMA in excess of the ODWO over many years may be at increased risk of developing some form of cancer. NDMA accounted for 16% of all exceedances; most were attributable to the treatment chemical and disappeared when the water works discontinued its use.

Pesticides
Atrazine is the pesticide most commonly detected in Ontario's municipal drinking water. This pesticide was detected at levels ranging from .05 – 2.90 µg/L, at six water works. The ODWO for atrazine in drinking water is 5 µg/L. The presence of atrazine and other pesticides at trace levels indicates that the raw water source is adversely affected by agricultural activity. No pesticides were detected at levels greater than the ODWO.

Polychlorinated Biphenyls (PCBs)
Results of the DWSP show that PCBs have never been detected in either the treated drinking water or the raw water.

Polycyclic Aromatic Hydrocarbons (PAHs)
The presence of *PAHs* in the environment is principally associated with the combustion of organic matter, including fossil fuels. Seventeen PAHs are tested for in the DWSP. Benzo(a)pyrene is the only PAH for which an ODWO has been established. No PAHs were detected in treated drinking water.

Volatiles
Volatile organics are generally present in source water as a result of industrial activity. Twenty-six volatiles, in addition to disinfection by-products discussed above, are tested for in DWSP. Eleven volatiles were detected, none exceeded an ODWO.

Benzene was detected at three water works; the maximum level was 2.5 µg/L. The ODWO for benzene is 5 µg/L. One of the three water works subsequently shut down the contaminated wells in 1995 and the community is now supplied from a regional water supply. The detections of benzene at the other two water works were isolated incidents.

Carbon tetrachloride was detected at one water works on a single occasion at 2.2 µg/L. The ODWO for carbon tetrachloride is 5 µg/L. As of 1997, water is being supplied from an alternative source.

1,4-Dichlorobenzene was detected once in 1993 at 0.55 µg/L. The ODWO is 5 µg/L.

Ethylbenzene was detected once at each of five water works to a maximum level of 2.4 µg/L. There is no health-related ODWO established for ethylbenzene. The aesthetic objective is 24.0 µg/L.

Meta (plus para)-xylene was detected at nine water works to a maximum level of 6.2 µg/L. *Ortho-xylene* was detected at six water works. A health-related ODWO has not been established for either meta (plus para) – or ortho-xylene; however, the aesthetic objective for total xylenes in drinking water is 300 µg/L.

Styrene was detected once in 1993 at 2.2 µg/L. An ODWO has not been established for styrene in drinking water.

Tetrachloroethylene has been detected at three water works. The maximum level reported is 6.6 µg/L. The ODWO is 30 µg/L.

Toluene was detected at 11 water works to a maximum level of 2.1 µg/L. A health-related ODWO has not been established for toluene; however, the aesthetic objective is 24 µg/L.

1,1,1-Trichloroethane was detected at fourteen water works to a maximum level of 4.7 µg/L. An ODWO has not been established.

Trichloroethylene was detected at nine water works to a maximum level of 7.5 µg/L. The ODWO for trichloroethylene in drinking water is 50 µg/L.

3.2.5

Radionuclides

There are more than 200 radionuclides, some of which occur naturally and others which originate from human activity. The radionuclide of concern in the drinking water supplies in Ontario is tritium. *Gross beta* and *gross alpha* determinations are preliminary screens for all radionuclides, with the exception of tritium which must be measured separately. *Tritium* was detected in the treated water at 29 water supply systems, usually at background levels of between 7 and 10 Bq/L. The highest tritium concentration detected was 79 Bq/L. The ODWO for tritium in drinking water, 7000 Bq/L, is under review.

3.3

DWSP in Review

The DWSP steering committee, consisting of representatives from the Ministry of Health and the MOE's Laboratory Services Branch, Standards Development Branch, Water Policy Branch and Operations Division, conducts an annual review of the monitoring protocol. The following program modifications have been implemented as a result.

- In view of the intensive sampling conducted by individual operating authorities, sampling by DWSP for microbiological parameters was discontinued as of June 1996.
- DWSP results show that commonly used agricultural pesticides are rarely detected in the source waters in Northern Ontario. As a result, the frequency of pesticide analysis in this area has been reduced.
- DWSP results show that significant levels of pesticides are not detected in the Great Lakes. As a result, the frequency of pesticide sampling of raw water sources in non-agricultural rivers/watersheds has been reduced.
- DWSP results show that mercury and cyanide have never been detected in drinking water. As a result, once a baseline is established for mercury and cyanide at each location, sampling for these parameters is discontinued.
- Since the ODWO for total phenols has been replaced with limits for specific chlorophenols, analysis for phenols has been discontinued.
- Gross beta and gross alpha determinations will be used as preliminary screens for all radionuclides, with the exception of tritium which will continue to be analysed.

4
Drinking Water in Other Jurisdictions

4.1
Other Provinces

Alberta and Quebec are the only provinces with regulations that adopt the Canadian Drinking Water Guidelines (CDWGs) as enforceable standards. All other provinces have adopted the CDWGs as objectives for drinking water quality. Ontario is the sole province that has set limits for contaminants in addition to those cited in the CDWGs, e.g., methane, PCBs, NDMA. Several provinces, like Ontario, incorporate legally enforceable criteria when granting approval for a water works. Approvals also include monitoring requirements: parameters to be monitored, frequency of monitoring, and reporting protocols.

Alberta's Environmental Protection Act provides for the regulation of water works systems that supply potable water. The Potable Water Regulation (AR 122/93) enables the Alberta Environmental Protection agency to regulate the operation of water works systems and establish standards for such facilities and their operators. The regulation also establishes requirements for potable water quality, including matters such as disinfection and fluoridation.

Quebec is the only province other than Ontario that routinely monitors and reports on drinking water quality. Its Ministry of Environment and Wildlife conducts a surveillance program that targets medium and large municipal systems in the province. Since 1985, the ministry has analysed the water of 25% of the municipal water systems (representing 60% of the population of Quebec) through various studies. Results for the period 1989-1994[III] show that the parameters most frequently exceeding drinking water standards were microbiological, turbidity, lead, trihalomethanes and atrazine.

4.2
Australia

The Australian Drinking Water Guidelines[IV] are based primarily on the latest (1993) World Health Organization recommendations, with some deviation for specific parameters (Appendix IV). The guidelines are not designed to be used as enforceable standards and, in general, legislation in Australia does not provide for enforceable quality standards. The guidelines provide an authoritative Australian reference on good drinking water quality, covering a wide range of microbiological, physical, chemical and radiological characteristics that determine water quality. The guidelines are applicable to all water intended for drinking with the exception of bottled or packaged water (covered by food legislation), irrespective of its source or where it is used.

There are no formal requirements for monitoring of drinking water in Australia. Guidance for sampling frequencies are contained within the 1996 Australian Drinking Water Guidelines, and address sampling frequencies for microbiological indicators within the distribution system. The guidelines recommend stringent follow-up monitoring and remedial action if microbiological monitoring indicates that pollution of drinking water has occurred.

For physical quality, organic and inorganic health-related and non-health-related chemicals, the recommended monitoring consists of an appraisal before any water supply comes into operation and after any major change, then monitoring at least once each year. If levels approach recommended guidelines, more frequent sampling is required.

Each water authority is responsible for the supply of drinking water and the monitoring

[III] L'eau Potable Au Québec – Un Second Bilan De Sa Qualité 1989 – 1994, Environnement et Faune de Québec, ISBN 2-550-31624-X

[IV] 1996 Australian Drinking Water Guidelines, ISBN 0642244634

of drinking water quality. In the states of Victoria and New South Wales, the Health departments are the primary regulators on drinking water quality.

In New South Wales, the drinking water is provided by private water corporations, water boards and local or county councils. Results for 1991-1997 indicate that the detection of pesticides in rural drinking water samples is increasing. Pesticides were detected in 33 rural water supplies; three reported levels exceeding the guideline values for DDT and profenophos. Fourteen pesticides were detected below guideline values.

Testing for trihalomethanes is conducted only by the larger water authorities. Since 1991, the Sydney Water Corporation, serving a population of 3.8 million, has complied with the guideline level of 200 µg/L for 94% to 100% of the time ,while the Hunter Water Corporation, serving a population of .46 million, has complied 100% of the time.

Compliance with chemical criteria ranges from 50% to 100%. Parameters of concern, particularly for the rural water supplies that collectively serve 1.5 million people, 850,000 of whom receive unfiltered water, include turbidity, fluoride, lead, arsenic, selenium and mercury.

4.3

Europe

4.3.1

Belgium

The Belgium drinking water quality guidelines are based on the European Community Drinking Water Directive (Appendix IV). Since 1988, each of the regions within Belgium has been given responsibility for environmental and health concerns. Drinking water quality guidelines have been developed primarily to ensure the protection of public health. In the Flanders region the development of guidelines is the joint responsibility of the Department of Planning and Environment and the Department of Health, whereas the Department of Health has the responsibility for the control and policing of drinking water quality. Further, where water quality issues may also be of national significance, the relevant minister of the Belgian government may also be involved. Similar arrangements are found in other regions.

Drinking water in Belgium is supplied by a number of water supply authorities or companies. Most of the water supply companies are owned by the local municipality. Since 1989, the drinking water guidelines in each region have been legally enforceable, and are applied at the point of delivery to the consumer. The requirements for monitoring are set out in the regional guidelines in accordance with the European Community (EC) Drinking Water Directive[V]. Prior to the use of a new drinking water source, a detailed analysis of the water quality is required, including any toxic or undesirable substances that may be present. Laboratories that the water supply authorities use for monitoring water quality must comply with the relevant standards set out in the legislation.

The typical level of compliance achieved in Belgium[VI] ranges from 80% to greater than 95%, depending on the parameter. Fluoride, nitrate, disinfection by-products, lead and the pesticides atrazine and simazine are typically the parameters contributing to non-compliance.

4.3.2

France

The French drinking water standards are based on the EC Directive and include the World Health Organization (WHO) guidelines. The French Decree of 1989 contains maximum acceptable concentrations of chemicals based on health and aesthetic

[V] EC Council Directive relating to the quality of water intended for human consumption (80/778/EEC) OJ No.L229,30.8.80
www.europa.eu.int/comm/sg/consolid/en/38010778/art_c.htm

[VI] May 1995 draft of 'Health and Community Services Review of Drinking Water Quality Criteria', an international review, provided to MOE by Victorian Department of Health and Community Services, Australia

considerations. The standards include monitoring requirements based on population size and pertain to all water intended for drinking, with the exception of bottled water.

The supply of drinking water is generally regarded as the responsibility of the municipality, while the drinking water standards are administered by the French Health Ministry. In many cases, the municipalities have contracted out the supply of water to private water companies, which at the very minimum must provide drinking water complying with French standards.

At present there is no nationalized monitoring and reporting system and no penalties are imposed by the local health authorities or Health Ministry for non-compliance with water quality standards. Compliance is not currently reported on a national basis. Data obtained from a survey conducted by the Health Ministry[VI] indicate compliance with the nitrate standard at 90% for large systems and 50% to 90% for small systems. Compliance with the turbidity standard of 2 NTU is 90%. No other data on health related parameters were reported.

4.3.3

The Netherlands

The Dutch guidelines are also based on the EC Directive. The provisions of the Directive are included in the relevant Dutch legislation and regulations. Drinking water quality is regulated under the Water Supply Act and the Water Supply Decree.

In the Netherlands, drinking water is supplied by a large number of water supply companies, some of which are privately owned. Others are owned by municipalities. The legally enforceable guidelines of the Act and Decree are applied to the outlet of the water treatment facility, within the distribution system and at the customer tap. The Regional Inspectorate of Public Health and Environmental Hygiene is the body responsibile for routine administration of the Act and Decree within each region. The Ministry of Health, Physical Planning and Environmental Protection is involved in establishing policy, granting exemptions and other drinking water issues.

Drinking water quality analyses are performed by official laboratories and the results of the monitoring reported directly to the local health authority. Water suppliers are not obliged to publish water quality monitoring results but are required to post them in the local mayoral offices for public information.

In general, a relatively high level of compliance is achieved by the Dutch water supply companies[VII], with almost all systems achieving greater than 95% compliance for the majority of parameters. The notable exception is lead, where the influence of lead plumbing results in 90% of supplies achieving greater than 95% compliance, and the remainder 80% to 95% compliance. Total coliforms, cadmium, turbidity, nitrate and trihalomethanes are typically the parameters contributing to non-compliance.

4.4

Japan

Water works in Japan are required to meet the Quality Standards of Drinking Water based on the Waterworks Law. The Quality Standards and the guidelines (Appendix IV) are established by the Ministry of Health and Welfare (MHW). The Waterworks Law outlines the monitoring requirements. An initial assessment of water quality must be conducted before starting up a water supply. Periodic examination, with daily monitoring of colour, turbidity and residual chlorine, and monthly monitoring of water quality standards is required.

The Quality Standards of Drinking Water are legally enforceable and administered by the MHW. The standards apply at the consumer's tap, and no exemptions or varia-

[VI] May 1995 draft of 'Health and Community Services Review of Drinking Water Quality Criteria', an international review, provided to MOE by Victorian Department of Health and Community Services, Australia

[VII] Correspondence to Dr. Sid Emami, MOE, from Dr. J. van den Berg,Manager Chemistry and Biology Department, KIWA N.V. July 19, 1995 re: Dutch drinking water quality

tions in the requirements are granted. Information on compliance is not collected on a national basis. Available data[VIII] provided on exceedances of health-related standards for the larger water supply systems indicate 99% compliance for the years 1990-1992. Turbidity, nitrate, coliforms and trihalomethane are typically the parameters contributing to non-compliance.

4.5

South Africa

The South African drinking water guidelines (Appendix IV), developed primarily to protect human health, are based on international guidelines from the EC, U.S. Environmental Protection Agency and WHO. The guidelines are not legally enforceable except under the conditions of the Health Act (Act 36 of 1977). Local governments are responsible for ensuring drinking water quality.

The results of water quality monitoring are reported to the health department of the local government. There is no requirement for the results to be made public. Action for non-compliance is carried out by the local authority, which is required to rectify any problems. The local authority has the power to close a water supply if the supply is deemed hazardous.

There is no national reporting system for drinking water quality compliance.

4.6

United States

The Safe Drinking Water Act (SDWA) governs drinking water in the United States. The SDWA allows states and territories to seek approval from the Environmental Protection Agency (EPA) to administer their own Public Water System Supervision (PWSS) Program. The authority to run a PWSS Program is called primacy. To receive primacy, states must meet specific requirements laid out in the SDWA and the regulations, including the adoption of drinking water regulations that are at least as stringent as the federal regulations and a demonstration that they can enforce the program requirements.

Under the SDWA, the EPA sets national limits on contaminant levels in drinking water (Appendix IV) to ensure that the water is safe for human consumption. These limits are known as Maximum Contaminant Levels (MCL). For some regulations EPA establishes treatment techniques (TT) in lieu of an MCL to prevent unacceptable levels of contamination in the finished water. The EPA also regulates the frequency of monitoring, the analytical method to be used and the protocol for reporting results to the state or EPA. The EPA requires public water systems to notify the public when they have violated any of the regulations.

The 1996 SDWA Amendment requires states with primacy to prepare and submit to the EPA an annual report on public water system violations[IX]. In 1996, regulations for 80 individual contaminants were in effect (71 have MCLs and nine are regulated by treatment techniques). This list comprises six microorganisms, four radionuclides, 16 inorganic chemicals and 54 organic chemicals.

In 1996 there were 55,427 Community Water Systems (CWSs) serving a population of 246,624,000[X]. Surface water is the source for 19% of the CWSs and ground water the source for 81%. Eighty-six per cent of CWSs are classified as very small or small in that each regularly serves 3,300 or fewer people. These small and very small systems serve fewer than 26 million people, or 10% of the population served by CWSs. Medium, large and very large systems represent 14% of all CWSs but serve 90% of the population.

[VIII] Correspondence to Dr. Sid Emami, MOE from Saburo Hosada, Chief Researcher, Water Supply Technology Institute, July 10, 1995 re: Japan's Drinking Water Quality

[IX] www.epa.gov/safewater/dwinfo.htm

[X] The National Public Water System Supervision Program - FY 1996 Compliance Report, U.S. Environmental Protection Agency Office of Enforcement and Compliance Assurance

For the years 1992-1996 approximately 8% of CWSs in the United States annually violated MCL standards. Over 85% of MCL violations were for microbiological parameters or turbidity. Violations of MCLs for other contaminants are 0.17% annually for organics, 0.5-0.7% annually for inorganics and 0.5% for radionuclides. Parameters that commonly exceed drinking water standards include atrazine, nitrate, trihalomethanes, tetrachloroethylene and trichloroethylene.

SDWA amendments also gave the EPA the mandate to require each community water system to provide every customer with a Consumer Confidence Report (CCR)[IX] every 12 months. This report must contain information on the quality of the water supplied and characterize any risks from exposure to contaminants in an accurate and understandable manner.

4.7

United Kingdom

Drinking water in the United Kingdom must meet the quality standards (Appendix IV) laid down in the EC Directive. The EC Drinking Water Directive sets standards for a range of microbiological, physical and chemical properties (called parameters). In most cases the Directive states the Maximum Admissible Concentration (MAC) for these parameters and the minimum frequency at which tests for each parameter must be carried out.

The requirements of the EC Directive were incorporated into legislation in England and Wales in the Water Supply (Water Quality) Regulations, which took full effect in 1990. In some respects, these Regulations are more stringent than the European Directive. In addition, they extend controls by adding national standards and providing detailed requirements for sampling, publication of information and other key areas associated with quality.

The Regulations are enforced by the government's Drinking Water Inspectorate, which regularly carries out inspections, audits and investigations. The water companies carry out the statutory sampling of the water supplied to the customers, and more than three million tests are carried out and reported annually to the Inspectorate. The results are audited and published in an annual report[XI].

About 50 million people in England and Wales are supplied with 16,800 million litres of water daily by 20 water companies. That is about 99% of the population. There are some 1,500 water treatment works. The water is always treated by disinfection, often by filtration, and sometimes by more complex processes. Of the three million tests carried out in 1996 by the 29 water companies, 99.7% met the drinking water standards. Parameters that exceeded drinking water standards include microbiological, coliforms and fecal coliforms, turbidity; nitrite, lead, polyaromatic hydrocarbons (PAHs) and individual pesticides.

[XI] Summary of the United Kingdom 1996 Report by the Drinking Water Directive www.the-stationary-office.co.uk/document/doe/drinking/summ.htm and www.dwi.detr.gov.uk/annrep98

5
Discussion

All drinking water may reasonably be expected to contain at least small amounts of some contaminants. Their presence does not necessarily indicate that the water poses a health risk. Completely removing all contaminants would be extremely expensive, and in nearly all cases would not provide greater protection of health.

Drinking water quality is largely dependent on the quality of the source water, which can vary greatly between watersheds and geographic locations. Ground water has very different characteristics from surface water; the quality of both is dependent on the type of geologic formations the water passes through, the length of contact time for leaching of chemicals, and land use practices such as farming and industrial activity.

Additionally, the criteria used throughout the world to assess quality of drinking water vary greatly. This is due to variability in source water, water quality standards, level of treatment required, monitoring protocols and analytical methods used for testing. Rather than reporting the complete spectrum of analytical results, as the DWSP does, most jurisdictions report on violations. These violations may be of monitoring or treatment requirements or exceedances of prescribed water quality standards. Appendices VI and VII compare the most recent drinking water violations available for several U.S. states, a U.K. operating authority, Japan and the Netherlands, as reported by the regulating authority.

Comparison of the results indicate that lead, nitrate/nitrite, trihalomethanes and turbidity are common problems for all jurisdictions. Fluoride violations are only reported by Ontario due to our stringent standard; however if the less stringent standard used by the U.S., 4.0 mg/L, were applied in Ontario, no violations would be reported in Ontario. Similarly if the total trihalomethanes standard of 100 µg/L, based on four quarterly samples, were applied to Ontario's results, (pre-June 1996), the number of violations would increase. No jurisdiction outside Ontario is monitoring for the presence of N-nitrosodimethlyamine in drinking water.

The U.K. Severn-Trent water supply system historically reports numerous violations with the standard for PAHs (polycyclic aromatic hydrocarbons). PAHs, including Benzo-3,4-pyrene, are substances associated with fossil fuels. When found in drinking water they often originate in coal tar linings of old distribution mains.

Comparing drinking water quality based on the violations reported is further complicated by the unavailability of information on monitoring frequency and number of tests conducted. For the 1993-1997 period, the DWSP monitored drinking water quality at each water supply at a frequency varying from one to twelve or more times per year. This far exceeds the monitoring requirements established under the U.S. Safe Drinking Water Act for most parameters.

6 Conclusions

Through the Ministry of the Environment's drinking water monitoring programs and legislative and regulatory programs, Ontario demonstrates due diligence in ensuring that the drinking water provided by municipal water systems is of a good quality and meets all health-related objectives.

Where other jurisdictions may require monitoring and reporting only for parameters for which limits have been set as objectives, guidelines or standards, the DWSP monitors drinking water quality for over 200 parameters, including those for which Ontario Drinking Water Objectives have been set.

The Drinking Water Surveillance Program (DWSP) is a comprehensive monitoring program that follows a standardized sampling protocol, conducts analytical testing at the MOE laboratory using standardized methods, and ensures that quality assurance/quality control protocols are followed.

Since the DWSP monitors drinking water quality for over 200 parameters, occurrence data can be used to support the development of new objectives and revision or elimination of existing ones. Ontario is the only province that can provide such reliable data on drinking water to the Canadian federal-provincial sub-committee in support of standards setting.

By monitoring the water at the different stages of the treatment process, ministry staff can provide valuable technical assistance to municipal staff regarding treatment efficiency.

Ontario is blessed with an abundant supply of good quality source water, surface and ground. Results of the DWSP continue to demonstrate that the drinking water provided to consumers is of good quality. In fact, the quality of drinking water in Ontario compares with or surpasses the quality of that provided by other jurisdictions.

APPENDIX I

Ontario Drinking Water Objectives

Chemical/Physical Health-Related

PARAMETER	MAC (mg/L)	IMAC (mg/L)	POTENTIAL HEALTH EFFECTS FROM INGESTION OF WATER	SOURCES IN DRINKING WATER
Alachlor		0.005	Cancer	Herbicide for corn, soybeans
Aldicarb	0.009		Neural, cholinergic effects	Insecticide use
Aldrin + Dieldrin	0.0007		Liver, nervous effects	Insecticide use
Arsenic		0.025	Skin,nervous system toxicity	Natural deposits; smelters, orchards
Atrazine		0.005	Mammary gland tumours	Herbicide for corn
Azinphos-methyl	0.02			Insecticide use
Barium	1.0		Circulatory system effects	Natural deposits, industrial effluent
Bendiocarb	0.04			Insecticide use
Benzene	0.005		Cancer	Industrial effluent, air pollution
Benzo(a)pyrene	0.00001		Cancer	Coal tar, burning organic matter
Boron		5.0	Kidney effects	Natural, industrial/agricultural effluent
Bromoxynil		0.005	Kidney, thyroid effect	Herbicide for grains
Cadmium	0.005		Kidney effects	Natural deposit, batteries, plumbing
Carbaryl	0.09			Insecticide use, ectoparasite control
Carbofuran	0.09		Nervous, reproductive system effects	Insecticide use
Carbon Tetrachloride	0.005		Cance	Solvents/ degradation products
Chloramines	3.0			By-product of chlorine+ ammonia
Chlordane	0.007		Cancer	Insecticide use
Chlorpyrifos	0.09			Insecticide use, ectoparasite control
Chromium	0.05		Liver, kidney, circulatory disorders	Natural deposits, electroplating
Cyanazine		0.01		Herbicide use
Cyanide	0.2		Thyroid, nervous system damage	Electroplating, mining, industrial use
Diazinon	0.02			Insecticide use
Dicamba	0.12			Herbicide use
1,2-Dichlorobenzene	0.2			Industrial effluent
1,4-Dichlorobenzene	0.005		Cancer	Room deodorants, mothballs
DDT+metabolites	0.03			Pesticide use
1,2-Dichloroethane		0.005	Cancer	Leaded gasoline, fumigants, paints
1,1-Dichloroethylene	0.014			Synthetic organic
Dichloromethane	0.05		Cancer	Paint stripper, metal degreaser
2,4-Dichlorophenol	0.9			Industrial effluent
2,4-D		0.1	Liver and kidney damage	Herbicide for wheat, corn
Diclofop-methyl	0.009			Pesticide use
Dimethoate		0.02		Insecticide use
Dinoseb	0.01		Thyroid, reproductive organ damage	Herbicide use
Dioxin and Furan		0.000000015 (a)	Cancer	Chemical production by-product
Diquat	0.07		Liver, kidney, eye effects	Herbicide use
Diuron	0.15			Herbicide use
Fluoride	(b)		Skeletal and dental fluorosis	Natural deposits, water additive
Glyphosate		0.28	Liver, kidney damage	Herbicide use
Heptachlor/Heptachlor Epoxide	0.003		Cancer	Insecticide use

Chemical/Physical Health-Related *(cont'd)*

PARAMETER	MAC (mg/L)	IMAC (mg/L)	POTENTIAL HEALTH EFFECTS FROM INGESTION OF WATER	SOURCES IN DRINKING WATER
Lead	0.01(c)		Kidneys, nervous system damage	Natural deposit, plumbing, solder
Lindane	0.004		Liver, kidney, nerve, immune, circulation	Insecticide use
Malathion	0.19			Insecticide use
Mercury	0.001		Kidney, nervous system disorders	Industrial effluent, pesticide use
Methoxychlor	0.9		Growth, liver, kidney, nerve effects	Insecticide use
Metolachlor		0.05		Herbicide use
Metribuzin	0.08			Herbicide use
Monochlorobenzene	0.08			Industrial effluent
Nitrate (as nitrogen)	10.0(d)		Methaemoglobinaemia	Fertilizers, domestic/animal waste
Nitrite (as nitrogen)	1.0(d)		Methaemoglobinaemia	same as nitrate
Nitrate + Nitrite (as nitrogen)	10.0(d)		Methaemoglobinaemia	
Nitrilotriacetic Acid (NTA)	0.4		Kidney effects	Laundry detergents
Nitrosodimethylamine (NDMA)		0.000009		Industrial effluent
Paraquat		0.01		Herbicide use
Parathion	0.05			Insecticide use
Pentachlorophenol	0.06		Liver and kidney effects, cancer	Herbicide use, wood preservative
Phorate		0.002		Insecticide use
Picloram		0.19	Kidney, liver damage	Herbicide use
Polychlorinated Biphenyls (PCB)		0.003	Cancer	Coolant oils - electrical transformers
Prometryne		0.001		Herbicide use
Selenium	0.01		Liver damage	Natural deposits, mining, smelting
Simazine		0.01	Cancer	Herbicide use
Temephos		0.28		Insecticide use
Terbufos		0.001		Insecticide use
Tetrachloroethylene	0.03		Liver effects	Dry cleaning solvent
2,3,4,6-Tetrachlorophenol	0.10			Wood preservative
Triallate	0.23			Herbicide use
Trichloroethylene	0.05		Cancer	Textiles, adhesives, metal degreaser
2,4,6-Trichlorophenol	0.005			Manufacture of pesticides
2,4,5-T	0.28			Herbicide use
Trifluralin		0.045		Herbicide use
Trihalomethanes	0.10(e)		Cancer	By-product of chlorination
Turbidity	(f)		Interferes with disinfection	Soil runoff
Uranium	0.10 (g)		Kidney damage	Natural deposits
Vinyl Chloride	0.002		Cancer	Synthetic organic, PVC pipes

APPENDIX I

Ontario Drinking Water Objectives

Chemical/Physical Objectives – Non Health-Related

PARAMETER	OBJECTIVE (mg/L – unless otherwise specified)	TYPE OF OBJECTIVE
Alkalinity (as CaCO3)	30-500	OG
Aluminum	0.10	OG
Chloride	250	AO
Colour	5 TCU	AO
Copper	1.0	AO
Dissolved Organic Carbon	5.0	AO
Ethylbenzene	0.0024	AO
Hardness (as CaCO3)	80-100	OG
Iron	0.30	AO
Manganese	0.05	AO
Methane	3L/m³	AO
Odour	Inoffensive	AO
Organic Nitrogen	0.15	OG
pH	6.5-8.5 (no units)	OG
Sodium	(h)	AO
Sulphate	500 (i)	AO
Sulphide	0.05	AO
Taste	Inoffensive	AO
Temperature	15°C	AO
Toluene	0.024	AO
Total Dissolved Solids	500	AO
Xylenes	0.30	AO
Zinc	5.0	AO

(a) Total toxic equivalents when compared with 2,3,7,8-TCDD (tetrachlorodibenzo-p-dioxin)

(b) The MAC of 1.5 mg/L was established to ensure that when fluoride is added to drinking water, the concentration (1.2 +/- 0.2 mg/L) is maintained. This level provides optimal benefit in the prevention of dental caries with absence of mottling of teeth or skeletal fluorosis.

(c) This objective applies to water at the point of consumption. Since lead is a component in some plumbing systems, first flush water may contain higher concentrations of lead than water that has been flushed for five minutes. Faucets, therefore, should be thoroughly flushed before water is taken for consumption.

(d) Where nitrate and nitrite are present, the total of the two should not exceed 10 mg/L.

(e) 2,4,5-trichlorophenoxy acid.

(f) A MAC for turbidity of 1 NTU in drinking water leaving the treatment plant was established to ensure the efficiency of the disinfection process. Treatment processes can result in increased turbidity in the distribution system. To ensure that the aesthetic quality is not degraded, an aesthetic objective for turbidity at the free flowing outlet of the ultimate consumer has been set at 5 NTU.

(g) The MAC for trihalomethanes is based on a running quarterly average.

(h) The aesthetic objective for sodium in drinking water is 200 mg/L. The medical officer of health should be notified when the sodium concentration exceeds 20 mg/L so that this information may be disseminated to local physicians for their use with patients on sodium restricted diets.

(i) When sulphate levels exceed 500 mg/L, water may have a laxative effect on some people.

Abbreviations Used:

MAC	Maximum Acceptable Concentration
IMAC	Interim Maximum Acceptable Concentration
AO	Aesthetic Objective
OG	Operational Guideline
NTU	Nephelometric Turbidity Unit
mg/L	milligrams per litre
TCU	True Colour Units
Bq/L	Becquerels per litre

APPENDIX I

Ontario Drinking Water Objectives

Microbiological Objectives – Health Related

PARAMETER	MAC (per 100 mL)
Total Coliforms	see below
Escherichia coli and/or Fecal Coliforms*	not detected
General Bacterial Population	**

Remedial action must be taken if one of the following occurs:

(1) Total coliform bacteria are detected in consecutive samples from the same site or in multiple samples taken as a single submission from a distribution system.

(2) *Escherichia coli* (E. Coli) and/or fecal coliforms are detected in any distribution sample.

(*) *Escherichia coli* is a more definitive indicator of fecal contamination than other fecal coliforms or total coliforms.

(**) At elevated levels, the general bacterial population may interfere with the detection of coliforms. This general population can be estimated from either background colony counts on the total coliform membrane filters or heterotrophic plate counts (HPC). If the membrane filter contains more than 200 background colonies on a total coliform medium per 100 mL or if the HPC exceeds 500 colonies per mL, the site should be resampled. If there is a recurrence of unacceptable background plate counts, an inspection of the site should be undertaken to determine the cause.

Radionuclide Objectives – Health Related

PARAMETER	MAC (Bq/l)
Cesium-137	50
Iodine-131	10
Radium-226	1
Strontium-90	10
Tritium	7000

Notes:
Radionuclide concentrations that exceed the MAC may be tolerated for a short duration, provided that the annual average concentrations remain below the MAC and the restriction (see immediately below) for multiple radionuclides is met.

Restrictions for multiple radionuclides: If two or more radionuclides affecting the same organ or tissue are present, the following relationship based on International Commission on Radiological Protection (ICRP) Publication 26, should be satisfied:

$$\frac{c_1}{C_1} + \frac{c_2}{C_2} + \ldots\ldots\ldots\ldots\ldots\ldots \frac{c_i}{C_i} \leq 1$$

where c_1, c_2, and ci are the observed concentrations, and C_1, C_2, and Ci are the maximum acceptable concentrations for each contributing radionuclide.

APPENDIX II:

DWSP Sampling Locations (as of December 1997)

Plant Name	Population Served
Ajax WTP	105,472
Alexandria WTP	3,194
Alvinston WTP	920
Amherstburg WSS	16,638
Atikokan WTP	4,100
Aurora Well Supply	25,137
Barrie Well Supply	55,000
Beardmore WTP	425
Beaverton WTP	2,740
Belle River WTP	16,000
Belleville WTP	36,792
Blezard Valley Well Supply	28,302
Bourget Well Supply	841
Bowmanville WTP	15,123
Bracebridge WTP	6,186
Brantford WTP	77,197
Brockville WTP	24,000
Burlington WTP	120,000
Cambridge Well Supply	85,062
Capreol Well Supply	3,671
Casselman WTP	2,500
Cayuga WTP	(plant closed 1995)(1)
Chapleau WTP	2,450
Charlottenburgh WTP	620
Chatham WTP	45,900
Clarence Creek WTP	705
Cobourg WTP	13,287
Cochenour WTP	700
Collingwood WTP	12,500
Cornwall WTP	46,000
Delhi WTP + Well Supply	4,182
Deseronto WTP	2,349
Dorchester Well Supply	4,500
Dowling Well Supply	1,851
Dresden WTP	(plant closed 1997)(2)
Dryden WTP	6,500
Dunnville WTP	5,155
Ear Falls WTP	1,000
Elgin (St Thomas) WSS	51,921
Elmira Well Supply	(closed in 1994)(3)
Emo WTP	875
Erin Well Supply	2,500
Fort Erie - Rosehill WTP	22,803
Fort Frances WTP	9,000
Garson Well Suppply	5,272
Goderich WTP	7,500
Gravenhurst WTP	5,500
Grimsby WTP	25,127
Guelph Well Supply	80,000
Haldimand-Norfolk WSS	3,960
Hamilton WTP	412,000
Harrow-Colchester S. WSS	6,000
Hawkesbury WTP	9,666
Huntsville WTP	10,000
Ingersoll Well Supply	9,378
Ingleside WTP	1,755
Kenora WTP	13,500
Kingston WTP	75,000
Kitchener Well Supply	157,379
Kitchener (Mannheim)WTP	as above
Lindsay WTP	17,000
London (Lake Huron) WSS	337,387
Manitouwadge Well Supply	4,500
Marathon Well Supply	5,065
Midland Well Supply	14,300
Milton Well Supply	23,203
Mitchell's Bay WTP	(plant closed 1996)(2)
Napanee WTP	8,500
Newmarket Well Supply	30,458
Niagara Falls WTP	69,032
Nipigon WTP	2,392
North Bay WTP	55,165
Norwich Well Supply	2,350
Oakville WTP	98,400
Odessa WTP	2,405
Ohsweken WTP *	2,000
Orangeville Well Supply	17,227
Orillia WTP	27,000
Oshawa WSS	124,000
Ottawa (Britannia) WTP	650,000
Ottawa (Lemieux Is) WTP	as above
Otterville Well Suppply	905
Owen Sound WTP	15,000
Owen Sound Well Supply	as above
Paisley WTP	1,078
Pembroke WTP	13,595
Penetanguishene Well Supply	6,000
Perth WTP	5,500

APPENDIX II:

DWSP Sampling Locations (as of December 1997)

Plant Name	Population Served
Peterborough WTP	68,871
Picton WTP	6,000
Plantagenet WTP	876
Port Colborne WTP	15,092
Port Dover WSS	5,515
Port Elgin WTP	8,627
Port Hope WTP	12,500
Port Perry Well Supply	5,835
Port Stanley	(plant closed 1996)(4)
Port Rowan WTP	953
Prescott WTP	6,000
Rainy River WTP	1,000
Red Lake WTP	2,061
Red Rock WTP	1,237
Renfrew WTP	7,837
Rockland WTP	7,746
Sarnia (Lambton Area)WSS	103,000
Sault Ste. Marie Well Supply	79,500
Sault Ste. Marie WTP	as above
Simcoe Well Supply	14,956
Sioux Lookout WTP	3,700
Smiths Falls WTP	11,006
South Peel (Lakeview) WSS	700,000
South Peel (Lorne Park) WSS	as above
Southampton WTP	4,784
St Catharines (DeCew) WSS	150,509
St. Pascal de Baylon Well Supply	250
Stoney Point (Tilbury North) WSS	3,481
StouffvilleWell Supply	1,100
Stratford Well Supply	28,025
Sudbury(David Street)WTP	90,453
Sudbury (Wanapitei)WTP	as above
Sunderland Well Supply	2,090
Tecumseh WTP	16,314
Terrace Bay WTP (5)	2,600
Thamesville Well Supply	985
Thunder Bay (Bare Point)WTP	114,550
Thunder Bay (Loch Lomond)WTP	as above
Tilbury WTP	5,618
Tillsonburg Well Supply	718
Toronto (F.J. Horgan) WT	2,600,000
Toronto Island WTP	as above
Toronto (R.C. Harris) WTP	as above
Toronto (R.L. Clark)WTP	as above

Plant Name	Population Served
Trenton WTP	20,000
Trenton Well Supply	as above
Union (Essex County) WWS	46,097
Wallaceburg WTP	11,496
Walpole Island WTP *	1,900
Waterford Well Supply	3,239
Waterloo Well Supply	72,355
Wawa WTP	4,003
Welland WSS	50,587
Whitby WTP	55,000
Windsor WTP	215,848
Woodstock Well Supply	28,300
Total Population	**7,842,634**

Legend

WTP	Water Treatment Plant
WSS	Water Supply System
*	First Nations water works
(1)	Drinking water supplied by Region of Hamilton-Wentworth
(2)	Drinking water supplied by Chatham
(3)	Drinking water supplied by Kitchener-Waterloo
(4)	Drinking water supplied by Elgin Area Water Supply
(5)	Privately owned water works

APPENDIX III

DWSP PARAMETERS (as of December 1997)

BACTERIOLOGICAL
Standard plate count

CHEMISTRY (FIELD)
Field chlorine residual (free, total, combined)
Field ph
Field temperature
Field turbidity

CHEMISTRY (LAB)
Alkalinity
Ammonium total
Calcium
Chloride
Colour
Conductivity
Dissolved organic carbon
Fluoride
Hardness
Ioncal
Langeliers index
Magnesium
Nitrates (total)
Nitrite
Nitrogen total kjeldahl
Ph
Phosphorus total
Potassium
Residue filtrate (calculated TDS)
Silicates
Sodium
Sulphate
Turbidity

CHLOROAROMATICS
1,2,3-trichlorobenzene
1,2,3,4-tetrachlorobenzene
1,2,3,5-tetrachlorobenzene
1,2,4-trichlorobenzene
1,2,4,5-tetrachlorobenzene
1,3,5-trichlorobenzene
2,3,6-trichlorotoluene
2,4,5-trichlorotoluene
2,6a-trichlorotoluene
Hexachlorobenzene (HCB)
Hexachlorobutadiene
Hexachloroethane
Octachlorostyrene
Pentachlorobenzene

CHLOROPHENOLS
2,4-dichlorophenol
2,3,4-trichlorophenol
2,3,4,5-tetrachlorophenol
2,3,4,6-tetrachlorophenol
2,3,5,6-tetrachlorophenol
2,4,5-trichlorophenol
2,4,6-trichlorophenol
Pentachlorophenol

HALOACETIC ACIDS
Monochloroacetic acid
Dichloroacetic acid
Trichloroacetic acid
Monobromoacetic acid
Dibromoacetic acid
Bromochloroacetic acid
Total haloacetic acids

METALS
Aluminum
Antimony
Arsenic
Barium
Beryllium
Boron
Cadmium
Chromium
Cobalt
Copper
Cyanide
Iron
Lead
Manganese
Mercury
Molybdenum
Nickel
Selenium
Silver
Strontium
Thallium
Titanium
Uranium
Vanadium
Zinc

N-NITROSODIMETHYLAMINE (NDMA)
NITRILOTRIACETIC ACID (NTA)

POLYNUCLEAR AROMATIC HYDROCARBONS (PAHs)
Anthracene
Benzo(a) anthracene
Benzo(a) pyrene
Benzo(b) chrysene
Benzo(b) fluoranthene
Benzo(e) pyrene
Benzo(g,h,i) perylene
Benzo(k) fluoranthene
Chrysene
Coronene
Dibenzo(a,h) anthracene
Dimethyl benzo(a) anthracene
Fluoranthene
Indeno(1,2,3-c,d) pyrene
Perylene
Phenanthrene
Pyrene

PESTICIDES & PCB
2,4 D propionic acid
2,4,5-trichlorophenoxy acetic acid
2,4-dichlorobutyric acid (2,4-D)
2,4-dichlororphenoxybutyric acid (2,4-DB)
2,4,5-TP (silvex)
Alachlor (lasso)
Aldrin
Alpha hexachlorocyclohexane
Alpha chlordane
Ametryne
Atratone
Atrazine
Desethyl atrazine
Azinphos-methyl
Barban
Beta hexachlorocyclohexane
Bromoxynil
Butylate (sutan)

APPENDIX III

DWSP PARAMETERS (as of December 1997)

Chlorpyrifos (dursban)
Cyanazine (bladex)
Carbaryl (sevin)
Carbofuran
Diallate
Diazinon
Dicamba
Dichlorovos
Diclofop-methyl
Dieldrin
Dimethoate
Diquat
Endosulfan 1 (thiodan i)
Endosulfan 2 (thiodan ii)
Endosulfan sulphate
Endrin
Eptam
Ethion
Gamma chlordane
Glyphosate
Heptachlor
Heptachlor epoxide
Hexachlorocyclopentadiene
Lindane
Malathion
Methoxychlor
Methyltrithion
Metolachlor
Metribuzin (Sencor)
Methylparathion
Mevinphos
Mirex
P,P-DDD
O,P-DDT
P,P-DDT
P,P-DDE
Oxychlordane
Paraquat
Parathion
PCB
Phorate (Thimet)
Picloram
Propham (IPC)
Prometone
Prometryne
Propoxur (Baygon)
Ipropazine
Reldan
Ronnel
Simazine
Desethyl simazine
Temephos
Terbufos
Toxaphene
Trifluralin

TASTE AND ODOUR

Geosmin
2-methylisoborneol

VOLATILES

1,1-dichloroethane
1,1-dichloroethylene
1,2-dichlorobenzene
1,2-dichloroethane
1,2-dichloropropane
1,3-dichlorobenzene
1,4-dichlorobenzene
1,1,1-trichloroethane
1,1,2-trichloroethane
1,1,2,2-tetrachloroethane
Benzene
Bromoform
Carbon tetrachloride
Chlorobenzene
Chlorodibromomethane
Chloroform
Cis 1,2-dichloroethylene
Dichlorobromomethane
Ethylene dibromide
Ethylbenzene
M-xylene
Methylene chloride
O-xylene
P-xylene
Styrene
Tetrachloroethylene
Trans 1,2-dichloroethylene
Toluene
Total trihalomethanes
Trichloroethylene
Vinyl chloride

RADIONUCLIDES

Tritium
Gross alpha count
Gross beta count
Cobalt 60
Cesium 134
Cesium 137
Iodine 131

APPENDIX IV
Drinking Water Limits in Other Jurisdictions

Physical/Chemical Characteristics

PARAMETER	UNIT	CANADA (MAC)[1]	UNITED STATES (MCL)[2]	EUROPEAN COMMUNITY (MADC)[3]	AUSTRALIA (GV)	JAPAN	SOUTH AFRICA
Acrylamide	mg/L		TT		0.002		
Alachlor	mg/L	0.005[5]	0.002				
Aldicarb + metabolites	mg/L	0.009					
Aldrin + Dieldrin	mg/L	0.0007			0.0003		
Aluminum	mg/L	0.10[14]	0.05-0.20[9]	0.05-0.20	0.2[8]	0.2[8]	
Antimony	mg/		0.006	0.01	0.003	0.002	
Arsenic	mg/L	0.005[5]	0.05	0.05	0.007	0.01	0.3
Asbestos	MFL		7				
Atrazine	mg/L	0.005	0.003		0.02		
Azinphos-methyl	mg/L	0.02					
Barium	mg/L	1	2	0.10[6]	0.7		
Bendiocarb	mg/L	0.04					
Benzene	mg/L	0.005	0.005		0.001	0.01	
Benzo(a)pyrene	mg/L	0.00001	0.0002	0.0002[7]	0.00001		
Beryllium	mg/L		0.004				
Boron	mg/L	5.0[5]		1	0.3	0.2	
Bromate	mg/L				0.02		
Bromoxynil	mg/L	0.005[5]					
Cadmium	mg/L	0.005	0.005	0.005	0.002	0.01	0.02
Carbaryl	mg/l	0.09					
Carbofuran	mg/	0.09	0.04				
Carbon Tetrachloride	mg/L	0.005	0.005		0.003	0.002	
Chloramines	mg/L	3					
Chloral Hydrate	mg/L				0.02		
Chlordane	mg/L		0.002		0.001		
Chloride	mg/L	≤250[8]	250[9]	25[8]	250[8]	200	600
Chlorine	mg/L				5		
Chlorine Dioxide	mg/L				1.0 0.40[8]		
Chlorite	mg/L				0.3		
Chloroacetic acid	mg/L				1		
Chlorobenzene (Monochlorobenzene)	mg/L	0.08	≤0.03[8]	0.1	0.30 0.01[8]		
2-Chlorophenol	mg/L				0.30 0.0001[8]		
Chlorpyrifos	mg/L	0.09					
Chromium	mg/L	0.05	0.1	0.05	0.05	0.05	
Colour	TCU	≤15[8]	15[9]	20	15	5	20
Copper	mg/L	≤1.0[8]	1.3[11]	0.10 (3.0 at the tap)	1.0[8]	1.5	
Cyanazine	mg/L	0.01[5]					
Cyanide	mg/L	0.2	0.2	0.05	0.07	0.01	0.2
Cyanogen Chloride	mg/L				0.07		
2,4-D	mg/L	0.10[5]	0.07		0.03		
Dalapon	mg/L		0.2				

APPENDIX IV
Drinking Water Limits in Other Jurisdictions

Physical/Chemical Characteristics

PARAMETER	UNIT	CANADA (MAC)[1]	UNITED STATES (MCL)[2]	EUROPEAN COMMUNITY (MADC)[3]	AUSTRALIA (GV)	JAPAN	SOUTH AFRICA
Diazinon	mg/L	0.02				0.005	
1,2-Dibromo-3-chloropropane (DBCP)	mg/L		0.0002				
Dicamba	mg/L	0.12					
Dichloroacetic acid	mg/L				0.05	0.04	
Dichloroacetonitrile	mg/L				0.08		
1,2-Dichlorobenzene	mg/L	0.20 ≤0.003[8]	0.6		1.5 0.001[8]		
1,3-Dichlorobenzene	mg/L				0.028		
1,4-Dichlorobenzene	mg/L	0.005 ≤0.001[8]	0.075		0.40 0.0003[8]	0.3	
1,2-Dichloroethane	mg/L	0.005[8]	0.005		0.003	0.004	
1,1-Dichloroethylene	mg/L	0.014	0.007		0.03	0.02	
cis-1,2-Dichloroethylene	mg/L		0.07		0.06	0.04	
trans-1,2-Dichloroethylene	mg/L		0.1		0.06	0.04	
Dichloromethane	mg/L	0.05	0.005		0.02	0.02	
2,4-Dichlorophenol	mg/L	0.90 ≤0.003[8]			0.20 0.003[8]		
1,2-Dichloropropane	mg/L		0.005				
1,2-Dichloropropanone	mg/L				0.6		
1,3-Dichloropropene	mg/L				0.002		
Diclofop-methyl	mg/L	0.009					
DDT	mg/L				0.02		
Di(2-ethylhexyl)adipate	mg/L		0.4				
Di(2-ethylhexyl)phthalate	mg/L		0.006		0.01	0.06	
Dimethoate	mg/L	0.025					
Dinoseb	mg/L	0.01	0.007				
Dioxin (2,3,7,8-TCDD)	pg/L	15	0				
Diquat	mg/L	0.07	0.02				
Diuron	mg/L	0.15					
EDTA[15]					0.25		
Endothall	mg/L		0.02				
Endrin	mg/L		0.002				
Epichlorohydrin	mg/L		TT		0.0005		
Ethylbenzene	mg/L	≤0.0024[8]	0.7		0.30 0.003[8]		
Ethylene dibromide	mg/L		0.00005				
Fluoride	mg/L	1.5	4.0 2.0[9]	1.5	1.5	0.8	1.5
Formaldehyde	mg/L				0.5	0.08	
Glyphosate	mg/L	0.28[5]	0.7				
Heptachlor	mg/L		0.0004		0.0003		
Heptachlor epoxide	mg/L		0.0002				
Hexachlorobenzene	mg/L		0.001				
Hexachlorobutadiene	mg/L				0.0007		
Hexachlorocyclopentadiene	mg/L		0.05				
Hydrogen Sulphide	mg/L	≤0.05[8]			0.05[8]		

APPENDIX IV
Drinking Water Limits in Other Jurisdictions

Physical/Chemical Characteristics

PARAMETER	UNIT	CANADA (MAC)[1]	UNITED STATES (MCL)[2]	EUROPEAN COMMUNITY (MADC)[3]	AUSTRALIA (GV)	JAPAN	SOUTH AFRICA
Iodide	mg/L				0.1		
Iron	mg/L	<0.30[8]	0.30[9]	0.20 0.05[8]	0.3[8]	0.3	1
Lead	mg/L	0.01	0.015[1]	0.05	0.01	0.05	0.1
Lindane	mg/L		0.0002		0.02		
Malathion	mg/L	0.19					
Manganese	mg/L	≤0.05[8]	0.05[9]	0.05 0.02[8]	0.50 0.10[8]		
Mercury	mg/L	0.001	0.002	0.001	0.001	0.0005	0.01
Methoxychlor	mg/L	0.9	0.04				
Metolachlor	mg/L	0.05[5]					
Metribuzin	mg/L	0.06					
Molybdenum	mg/L				0.05	0.007	
Monochloramine	mg/L				3		
Nickel	mg/L				0.02	0.01	
Nitrate	mg/L	45.0[11]	10	50.0[11]	50[11]	10	10
Nitrite	mg/L		1	0.1	3.0 (as nitrite)		
Nitrilotriacetic acid (NTA)	mg/L	0.4			0.2		
Odour		inoffensive[8]	3[9]	3	acceptable	3.0(8)	inoffensive
Oxamyl	mg/L		0.2				
PCBs	mg/L		0.0005	0.5			
Paraquat	mg/L	0.01[5]					
Parathion	mg/L	0.05					
Pentachlorophenol	mg/L	0.06 ≤0.03[8]	0.001				
pH			6.5-8.5[9]	9.5	6.5-8.5	5.8-8.6	5.5-9.5
Phenols	mg/L					0.005	10
Phorate	mg/L	0.002[5]					
Picloram	mg/L	0.19[5]	0.5				
Selenium	mg/L	0.01	0.05	0.01	0.01	0.01	0.05
Silver	mg/L		0.1[9]	0.01	0.02		
Simazine	mg/L	0.01[5]	0.004			0.003	
Sodium	mg/L	≤200[8]		150 20[8]	180[8]	200	400
Sulphate	mg/L	≤500[8]	250[9]	250 25[8]	250[8]		600
Styrene	mg/L		0.1		0.03 0.004[8]		
Taste		inoffensive[8]		3			
Temephos	mg/L	0.28[5]					
Terbufos	mg/L	0.001[5]					
Tetrachloroethylene	mg/L	0.03	0.005		0.05	0.01	
2,3,4,6-Tetrachlorophenol	mg/L	0.10 ≤0.001[8]					
Thallium	mg/L		0.002				
Toluene	mg/L	≤0.024[8]	1		0.80 0.025[8]	0.6	
Total Dissolved Solids (TDS)	mg/L	≤500[8]	500		500[8]	500[8]	
Total Trihalomethanes[16]	mg/L	0.10[5]	0.1		0.25	0.1	

APPENDIX IV
Drinking Water Limits in Other Jurisdictions

Physical/Chemical Characteristics

PARAMETER	UNIT	CANADA (MAC)[1]	UNITED STATES (MCL)[2]	EUROPEAN COMMUNITY (MADC)[3]	AUSTRALIA (GV)	JAPAN	SOUTH AFRICA
Toxaphene	mg/L		0.003				
2,4,5-TP (silvex)	mg/L		0.05				
Tributyltin oxide	mg/				0.001		
Trichloroacetic acid	mg/L				0.1	0.3	
Trichloroacetonitrile	mg/L					0.03	
1,2,4-Trichlorobenzene	mg/L		0.07		0.03 0.005[8]		
1,1,1-Trichloroethane	mg/L		0.2			0.3	
1,1,2-Trichloroethane	mg/L		0.005				0.006
Trichloroethylene	mg/L	0.05	0.005				0.03
2,4,6-Trichlorophenol	mg/L	0.005 ≤0.002[8]			0.02 0.002[8]		
Trifluralin	mg/L	0.045[5]					
Turbidity	NTU	1 5[8]	TT[12]	10	5[8]	2[8]	5
Uranium	mg/L	0.1			0.02		
Vinyl chloride	mg/L	0.002	0.002		0.0003		
Xylenes (total)	mg/L	≤0.3[8]	10		0.60 0.02[8]		0.4
Zinc	mg/L	≤5.0[8]	5.0[8]	0.10 5.0[13]	3	1	5

Footnotes

1. Maximum Acceptable Concentration (MAC) is a health-related objective established for parameters that when present above a certain concentration have known or suspected adverse health effects.
2. Maximum Contaminant Level (MCL) is the maximum permissible level of a contaminant in water delivered to any user of a public water system. MCLs are enforceable standards.
3. Maximum Admissible Concentrations (MADC) are concentrations below which substances in drinking water cannot, in the course of continuous ingestion, cause, or directly or indirectly, result in any adverse health effects to a statistically representative sampling of the population.
4. When acrylamide and epichlorhydrin are used in drinking water systems, the combination of dose and monomer level must not exceed the specific levels as follows:
   Acrylamide = 0.05% dosed at 1 mg/L (or equivalent)
   Epichlorhydrin = 0.01% dosed at 20 mg/L (or equivalent)
5. Interim Maximum Acceptable Concentrations (IMAC) are health-related objectives established for parameters when there is insufficient toxicological data to establish a MAC with reasonable certainty. When it is not feasible to establish a MAC at a desired level, an interim objective may be established at an achievable level.
6. A Guideline Level (GL) is a concentration in drinking water of a given substance that ideally should not be exceeded.
7. The European Community cites the MADC for total Polycyclic Aromatic Hydrocarbons.
8. Aesthetic Objectives are established for parameters that may impair the palatability (taste, smell, colour) of water or interfere with good water quality control practices.
9. National Secondary Drinking Water Regulations.
10. Action Levels trigger water systems into taking treatment steps if exceeded in more than 10% of tap water samples.
11. Equivalent to 10 mg/L as nitrate-nitrogen.
12. At no time can turbidity go above 5 NTU; systems that filter must ensure that the turbidity goes no higher than 1 NTU (0.5 for conventional or direct filtration) in at least 95% of the daily samples for any two consecutive months.
13. Guideline level of 0.1 mg/L for water leaving the facility, 5.0 mg/L after 12 hours in the distribution system.
14. Operational Guideline.
15. Ethylenediaminetetraacetic acid
16. Chloroform, Bromodichloromethane, Dibromochloromethane and Bromoform constitute trihaloemethanes, each individual trihalomethane or the sum of the trihaloemethanes must not exceed the guideline value.

Abbreviations

mg/L milligrams per litre; one part per million
MFL million fibres per litre
NTU nephelometric turbidity unit
PCB polychlorinated bphenyl
TCU total colour unit

APPENDIX II
Drinking Water Limits in Other Jurisdictions

Microbiological Characteristics Canadian Drinking Water Guidelines

The MAC for Coliforms in drinking water is zero organisms per 100 mL. Because coliforms are not uniformly distributed in water and are subject to considerable variation in enumeration, drinking water that fulfils the following conditions is considered to be in compliance with the coliform MAC:

1. No sample should contain more than 10 total coliform organisms per 100 mL, none of which should be fecal coliforms.
2. No consecutive sample from the same site should show the presence of coliform organisms; and
3. For community drinking water systems:
   - not more than one sample from a set of samples taken from the community on a given day should show the presence of coliform organisms; and
   - not more than 10% of the samples based on a minimum of 10 samples should show the presence of coliform organisms.

If any of the above criteria are exceeded, corrective action should be taken immediately.

Microbiological Characteristics Australia

Thermotolerant coliforms	not detected
Coliforms	not detected
E. Coli	not detected

Microbiological Characteristics Japan

1. Standard Plate Count	<100/mL
2. Total Coliforms	not detected

Microbiological Characteristics United States EPA

Giardia Lamblia	TT(1)
Heterotrophic Plate Count (HPC)	TT(1)
Total Coliforms (included fecal coliform and E. Coli)	5%(2)
Viruses (enteric)	TT(1)

1. The Surface Water Treatment Rule requires systems using surface water or ground water under the direct influence of surface water to a) disinfect and b) filter or meet criteria for avoiding filtration so that the following contaminants are controlled at the following levels:

Giardia Lamblia	99% killed/inactivated
Viruses	99% killed/inactivated
HPC	no more than 500 bacterial colonies per mL.

2. No more than 5% samples total coliform-positive in a month (for water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive). Every sample that has total coliforms must be analysed for fecal coliforms. There cannot be any fecal coliforms.

Radiological Characteristics United States EPA

Beta particles and photon emitters	4 millirems / year
Gross alpha particle activity	15 picocuries / L
Radium-226 and Radium-228 (combined	5 picocuries / L

Radiological Characteristics Australia

Radium-226	0.5 Bq/L
Radium-228	0.5 Bq/L
Radon-222	100 Bq/L

Microbiological Characteristics European Community

1. Total Coliforms	0/100 mL
2. Fecal Coliforms	0/100 mL
3. Fecal Streptococci	0/100 mL
4. Sulfite Reducing Clostridia: MPN <1/20 mL	
5. Total bacterial count in drinking water: a) 37 °C: 10/mL guide level b) 22 °C: 100/mL guide level	
6. Total bacterial count in conditioned water: a) 37 °C: 20/mL maximum acceptable b) 22 °C: 100/mL maximum acceptible	

Microbiological Characteristics South Africa

1. Total Coliforms	5/100 mL
2. Fecal Coliforms	0/100 mL
3. Standard Plate Count	100/mL

Radiological Characteristics Canadian Drinking Water Guidelines

Cesium-137	10 Bq/L
Iodine-131	6 Bq/L
Radium-226	0.6 Bq/L
Strontium-90	5 Bq/L
Tritium	7000 Bq/L

The MAC for radionuclides in public water systems is derived from adult dose conversion factors, assuming a daily water intake of 2 L and a maximum committed effective dose of 0.1 mSv, or 10% of the ICRP limit on public exposure:

$$MAC\ (Bq/L) = \frac{1 \times 10^{-4}\ (Sv/year)}{730\ (L/yr) \times DCF\ (Sv/Bq)}$$

Where two or more radionuclides that affect the same organ or tissues are found to be present in drinking water, the following relationship should be satisfied:

$$\frac{C1}{MAC_1} + \frac{C2}{MAC_2} + \cdots + \frac{Cl}{MAC_l} \leq 1$$

APPENDIX V

Ontario Municipal Water Supply Systems Exceedances of Health-related drinking Water Objectives

PARAMETER	MAC (mg/L)	1993		1994		1995		1996		1997	
		violations	# supplies	violations	# supplies	violations	# supplies	violations	# supplies	violations	# supplies
Fluoride	1.50	4	3	5	4	0	0	2	1	3	3
Lead	10.0	4	2	3	2	8	7	9	9	6	6
Nitrate (Total nitrate + nitrite)	10.0	2	1	1	1	1	1	0	0	1	1
N-nitrosodimethylamine (NDMA)	.000009	–	–	4	1	5	4	10	7	1	1
Total Trihalomethanes	.35	2	1	0	0	0	0	0	0	0	0
Turbidity	1 FTU	8	6	7	6	8	4	4	3	2	2

APPENDIX VI

United States Municipal Water Supply Systems Violations of Health-related Drinking Water Standards[xii]

PARAMETER	MAC (mg/L)	California 1997		Indiana 1996		Michigan 1998		New York 1998		Ohio 1997	
		violations	# supplies	violations	# supplies	violations	# supplies	violations	# supplies	violations	# supplies
Nitrate	10.0	5	5	30	17	2	2	5	5	4	4
Atrazine (pesticides)	0.003	–	–	2	1	–	–	–	–	1	1
Barium	2.0	–	–	2	1	–	–	–	–	–	–
Carbon Tetrachloride	0.005	–	–	1	1	2	1	–	–	–	–
Cyanide	0.20	1	1	–	–	–	–	–	–	–	–
Dichloromethane	0.005	–	–	2	2	–	–	–	–	–	–
Gross-alpha	15 pci	–	–	–	–	–	–	1	1	–	–
Tetrachloroethylene	0.005	–	–	–	–	–	–	1	1	–	–
Trichloroethylene	0.005	1	1	2	1	–	–	1	1	1	1
Total trihalomethanes	0.100	–	–	–	–	–	–	1	1	3	2
Surface Water Treatment Rule (turbidity)	*	9	6	6	5	6	3	20	13	261	48
Lead and Copper Rule	@	N/A	N/A	44	31	4	4	5	5	49	41

* The Surface Water Treatment Rule establishes treatment techniques in lieu of MCLs for *Giardia lambia*, viruses, bacteria, Legionella, heterotrophic plate count and turbidity. Treatment technique violations are typically reported as a result of raised turbidity levels in the water or a failure to maintain the required level of disinfection.

@ Lead and copper are regulated with "action levels" at the customer's tap. Concentrations above action levels indicate that water treatment for corrosion control may be inadequate. The action level for lead is 0.015 mg/L and for copper 1.3 mg/L. Violations may be reported as exceeding the action level or for not monitoring or reporting.

APPENDIX VII

International Water Supply Systems Violations of Health-Related Drinking Water Standards

PARAMETER	Severn-Trent (UK) 1998		Japan 1992		The Netherlands 1993	
	PCV (mg/L)	violations	Standard (mg/L)	violations	Standard (mg/L)	violations
Atrazine (pesticide)	0.001	1	–	–	–	–
Benzo-3,4-pyrene (PAH)	0.0001	6	–	–	–	–
Cadmium	–	–	–	–	0.005	2
Lead	0.05	20	–	–	–	–
Mecoprop (pesticide)	0.0001	1	–	–	–	–
Mercury	–	–	0.00005	6	–	–
Nitrate+nitrite	–	–	10.0 (as N)	5	50.0	1
Nitrite 0.10 8	0.10	8	–	–	–	–
Total PAH	0.0002	44	–	–	–	–
Total Pesticides	–	–	–	–	.0001	20
Total trihalomethanes	0.10	5	0.10	5	0.001	171
Turbidity	–	–	2 FTU	25	1 FTU	8